Forbes Lake Water Quality

A Report on Water Quality Monitoring Results
for Water Year 2012

Prepared for the City of Kirkland
by the King County Lakes and Streams Monitoring Group
Science and Technical Support,
Water and Land Resources Division
King County Department of Natural Resources and Parks

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King County

CITY OF KIRKLAND
WASHINGTON

Overview

In 2006, The King County Lakes and Streams Monitoring Group (KCLSM) and its predecessor the Lake Stewardship Program began monitoring water quality with volunteers on Forbes Lake, and efforts have continued through 2012. Physical and chemical data collected through five years of monitoring suggest that this small lake in the city of Kirkland is a mesotrophic to eutrophic lake with fair water quality.

Although there is no public access boat ramp, there are several public parcels adjacent to the lake, and opportunities exist for members of the public to access the lake at several locations, as well as to launch small car-top boats. This presents a potential vector for the introduction of noxious weeds to the lake. Residents should keep a watch on aquatic plants growing near shore to catch early infestations of Eurasian milfoil, Brazilian elodea, or other noxious weeds.

Later in this report references will be made to two common measures used to predict water quality in lakes: the Trophic State Index or TSI (Carlson 1977), and the ratio of nitrogen to phosphorus (N:P). The TSI values and N:P ratios were calculated from the data collected through the volunteer monitoring program. TSI values are derived from a regression that relates values of a parameter such as total phosphorus, chlorophyll *a* or Secchi transparency to algal bio-volume present, assigning a number on a scale of 0 to 100. This scale can be used to compare water quality over time and between lakes.

Further introduction and a discussion of the philosophy of the volunteer lake monitoring program and the parameters measured can be found on-line at:

http://your.kingcounty.gov/dnrp/library/archive-documents/wlr/waterres/smlakes/2006_Intro.pdf

The discussion in this report focuses on the 2012 water year. Specific data used to generate the charts in this report can be downloaded from the King County Lakes and Streams Monitoring data website at:

http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

Data can also be provided in the form of excel files upon request.

Physical Parameters

Excellent precipitation and water level records were compiled for the 2012 water year (Figure 1). Water levels followed a typical pattern for Puget Sound lowland lakes with lake levels high in the winter and dropping throughout the spring and summer. Because the area of the watershed is large relative to the size of the lake, surface water flow from the watershed is likely to affect lake levels more than direct precipitation on the surface of the lake. Data collected since May 2006 suggests the lake does not vary a great deal through the year in response to seasonality, although it will drop slowly during dry periods. Throughout 2012 the lake level varied around a relatively constant base level that may relate to groundwater levels, with short-lived increases that can mostly be attributed to rainfall and surface water runoff events. The highest lake levels do not appear to persist much longer than a week.

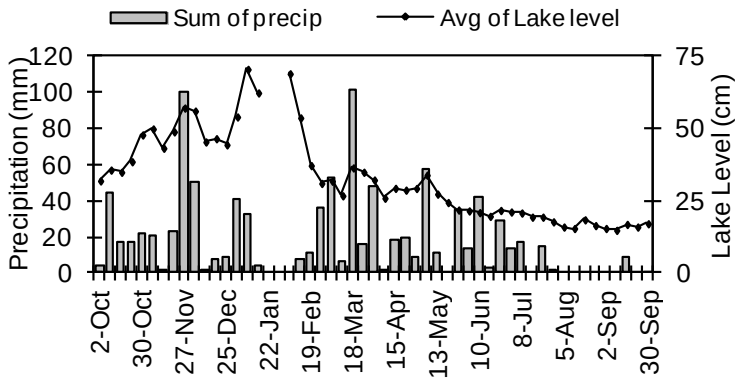

Figure 1. WY 2012 Forbes weekly lake level and precipitation

Volunteers collected Secchi transparency and temperature data from early May through late October during the "Level II" monitoring season when volunteers collect water samples for laboratory analyses. Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered into the water from the surface. Note that the Y-axis is traditionally reversed on Secchi charts to mimic looking into the water from the lake surface.

Secchi transparency from May through October ranged between 1.7 and 5.1 meters (Figure 2). The summer average transparency was 2.9 m, which placed it in the lower range of water clarity for monitored small lakes in 2012. There was a sharp drop in May from the deepest reading of 5.1 m to 2.5 m, and from that point on the Secchi readings were fairly consistent. This suggests that clarity dropped with the onset of summer biological activity; however, no algae blooms were identified that greatly impacted transparency at any time during the monitoring season.

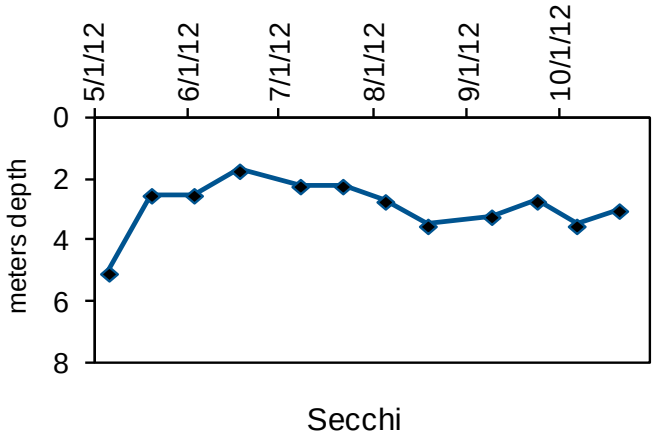

Figure 2. WY 2012 Forbes Secchi levels

Shallow water temperatures at 1 m ranged between 14.0 to 25 degrees Celsius, with an average of 19.5 degrees Celsius (Figure 3). The maximum temperature in late August coincided with the maxima at other lakes in the Puget Sound lowlands. As compared to 2011, weather patterns were more typical in the Puget Sound region than in the La Nina years of 2010-2011, and water temperatures responded by warming up faster and having a higher peak.

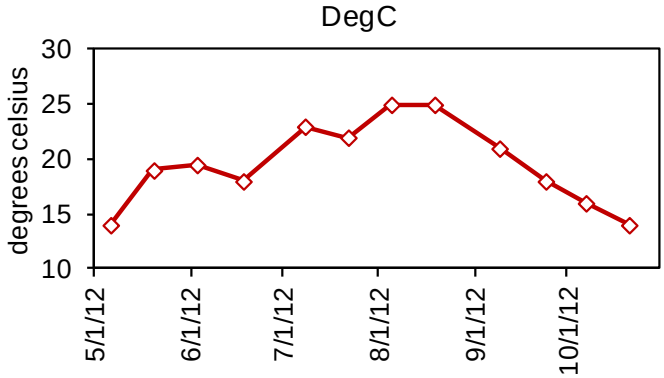

Figure 3. WY 2012 Forbes temperature

The average May – October temperature in 2012 was slightly warmer than the 2011 water year, but not as warm as in 2009 (Figure 4). The temperatures in 2009 may represent a sunnier than normal summer, while strong La Nina events occurred in both 2010 and 2011, related to cooler temperatures throughout the region. Further monitoring will help determine if Forbes Lake is increasing in temperature or remaining static, but currently there are not enough sequential years of data to analyze for trends.

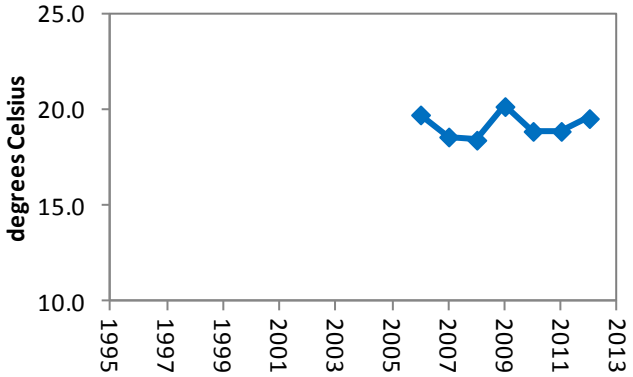

Figure 4: Forbes Lake average water temperature for May-October since 2006

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements that are necessary in small amounts for both plants and animals for healthy growth and reproduction. However, many actions associated with residential and commercial development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins.

Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth, between May and October, with deeper water analyzed twice through the season in May and August.

Throughout the monitoring period, nutrient concentrations remained stable with no large changes (Figure 5). TP declined slightly from June through mid-August, then increased to a somewhat higher level and remained stable through the fall.

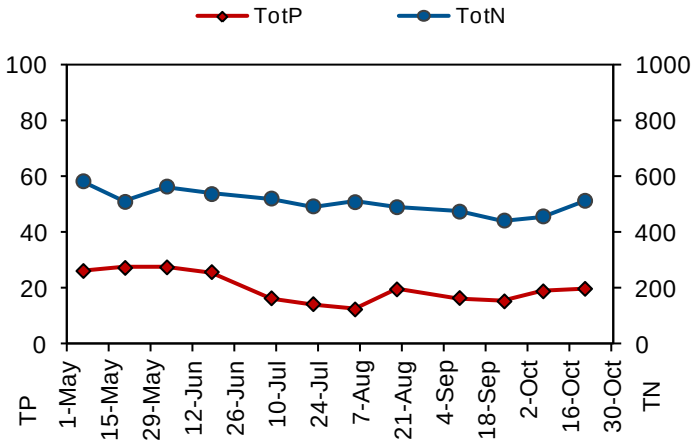

Figure 5. 2012 Forbes Lake total phosphorus and total nitrogen in ug/L.

The ratio of TN to TP can be used to determine if nutrient conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are near or below 20-25, cyanobacteria can dominate the algal community due to their ability to take nitrogen from the air.

Phosphorus and nitrogen remained in relatively constant proportion to each other through the sampling period, with the ratio (N:P) ranging from 18.6 to 40.8 with an average of 26.8 (Figure 6). Therefore nutrient conditions appeared to be favorable for bluegreens during the majority of the monitoring season with only the mid-summer period having N:P ratios that did not favor bluegreens.

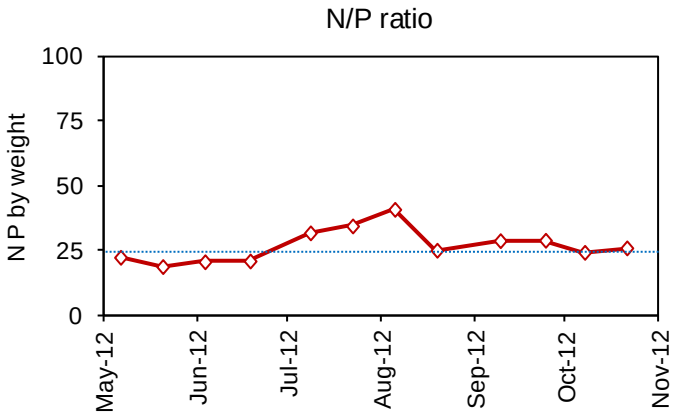

Figure 6: Forbes Lake N:P ratios. Values below the blue line indicate a potential nutrient advantage for cyanobacteria.

Chlorophyll *a* concentrations reached a maximum in early June followed by a decrease that was maintained until September, when an increase was followed by a lingering decrease to the end of the sampling period (Figure 7). Pheophytin, which is a degradation product of chlorophyll, was generally at low detection levels throughout the period. There was a spike in pheophytin that coincided with the spring peak seen in chlorophyll-*a*, which suggests that the higher chlorophyll values might have be due to sediment mixing into the shallow water.

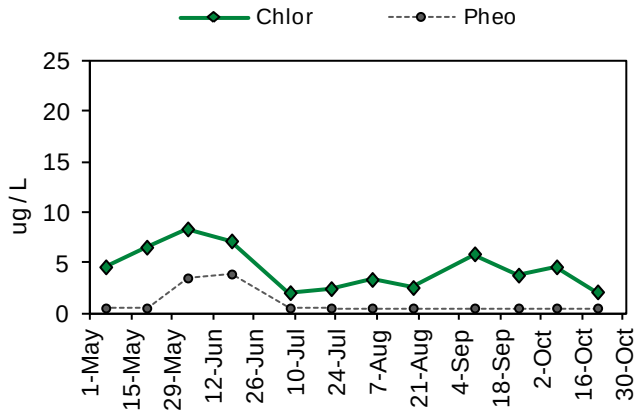

Figure 7. WY 2012 Forbes Chlorophyll *a* and Pheophytin concentrations

Water column profiles

Profile temperature data indicate that thermal stratification (temperature layering) was present in early summer and persisted through the second profile event in late August (Table 1). Higher concentrations of both total phosphorus and orthophosphate (dissolved inorganic phosphorus) were found in the deep water in May and especially in August, suggesting that anoxia (lack of oxygen) could have triggered a release of phosphorus from the sediments. The high ammonia (NH3) concentrations in the deep water also indicate deep water anoxia.

Chlorophyll *a* profile data indicate that algae are present throughout the water column, but were distributed unevenly in May, with higher concentrations present in the top and bottom waters. The highest concentration of algae occurred in the seven meter sample in the August profile, which suggests that at that time there was a reservoir of algae in the deep water, where nutrients were plentiful.

Table 1. Forbes Lake Profile Sample Analysis Results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 is in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red with the MDL value.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Forbes	5/20/12	2.5	1	19.0	6.53	**0.5**	0.511	0.011	0.0274	0.0064	0.315	57.4
Forbes			4	9.0	2.49	1.5	0.639		0.0300			
Forbes			7	6.0	4.99		0.827	0.309	0.0531	0.0232		
Forbes	8/19/12	3.5	1	25.0	2.53	**0.5**	0.492	0.006	0.0197	0.0027	0.270	65.7
Forbes			4	13.0	4.21	3.24	0.404		0.0222			
Forbes			7	8.0	26.9		1.380	0.938	0.2230	0.16		

The moderate values for UV254 indicate that the water of the lake is colored from organic substances, which probably is affecting the Secchi transparency values. The total alkalinity values show that the water in the lake is less soft than regional lakes in undeveloped watersheds and thus has more buffering capacity against pH change.

Trophic State Index Ratings

A common method of tracking water quality trends in lakes is by calculating values for the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI values predict the biological productivity of the lake. The TSI is based on water clarity (Secchi), concentrations of total phosphorus (TP), and chlorophyll *a*. The Index relates to three categories of productivity:

- *oligotrophic* (low productivity, below 40 on the TSI scale - low in nutrient concentrations, small amount of algae growth);
- *mesotrophic* (moderate productivity, between 40 and 50 on TSI scale – moderate nutrient concentrations, moderate growth of algae growth); and
- *eutrophic* (high productivity, above 50 – high nutrient concentrations, high level of algae growth).

In 2012 all three TSI indicators decreased and were close together in value, with the average of all three TSI indicator putting Forbes Lake into the mid mesotrophic range (Figure 8). The average of all three TSI indicators in 2012 put Forbes Lake into the upper mesotrophic range for the year and is the lowest recorded for Forbes Lake since monitoring began in 2006. Eight successive years of data are necessary to perform a reliable trend analysis to determine if the trophic status of Forbes Lake is relatively stable or may perhaps be following a decreasing trend in algal productivity.

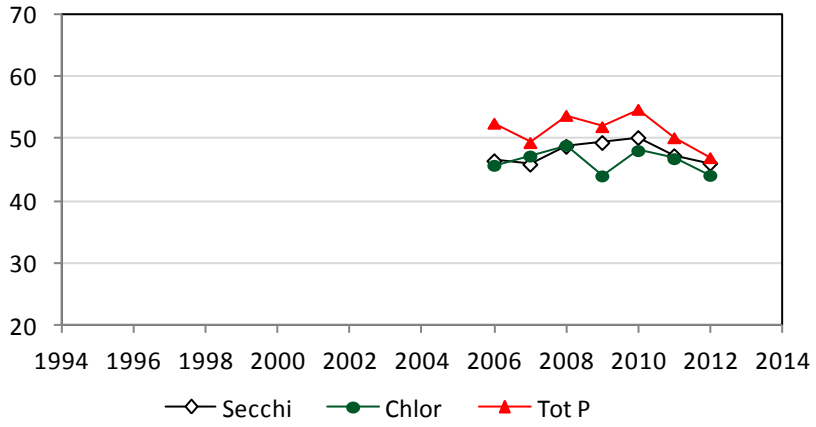

Figure 8. 2012 Forbes Lake Trophic State Indicators

Conclusions and Recommendations

Based on monitoring data, water quality in Forbes Lake has varied a little over the period measured and has shown both upward and downward variations from year to year. However, not enough data has been collected yet to verify a trend statistically or determine if there is a cyclical pattern in the lake. Low N:P ratios over the season could indicate nutrient conditions favorable for nuisance bluegreen algae blooms, particularly in the spring and late summer.

Monitoring of nutrient and chlorophyll concentrations should be continued to see if a trend can be verified. Close monitoring of algae blooms at the lake should also be done, including participation in the Washington State Department of Ecology's Toxic Algae Monitoring program, to determine whether or not blooms found in the lake may occasionally produce toxins.